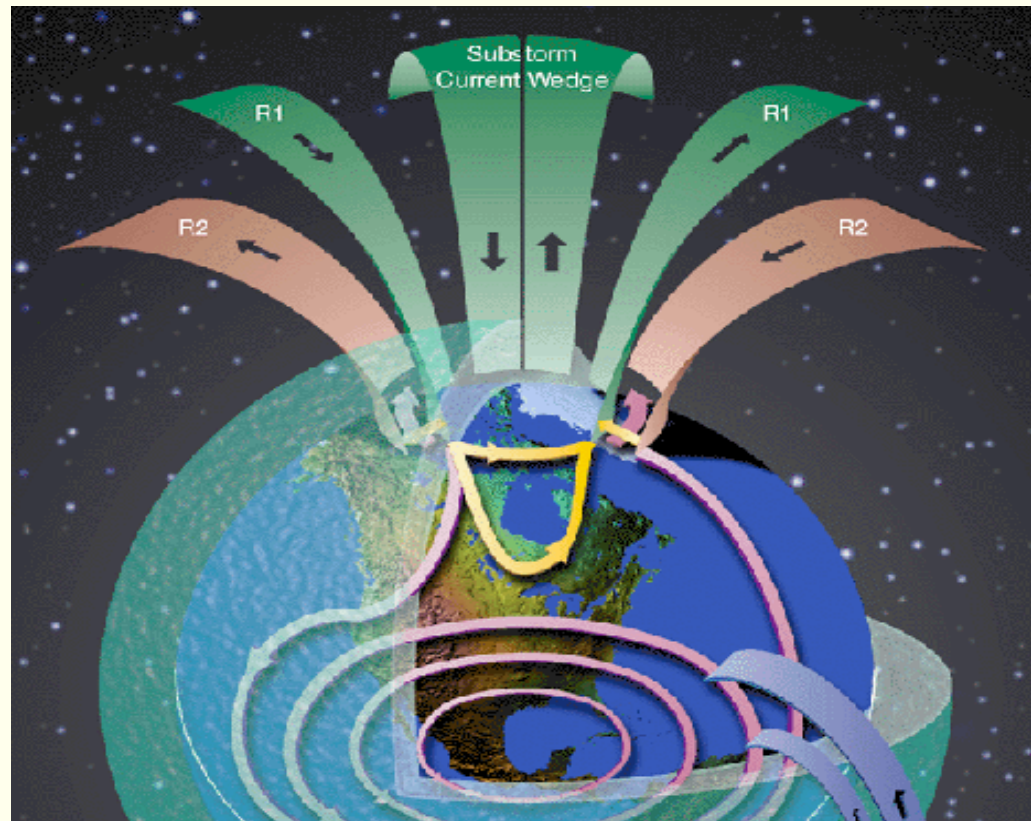


GEOSPACE ELECTRODYNAMIC CONNECTIONS (GEC)



25th EGS GENERAL ASSEMBLY, APRIL 2000

J. M. Grebowsky and J. C. Gervin NASA/GSFC

J. J. Sojka, Utah State U.

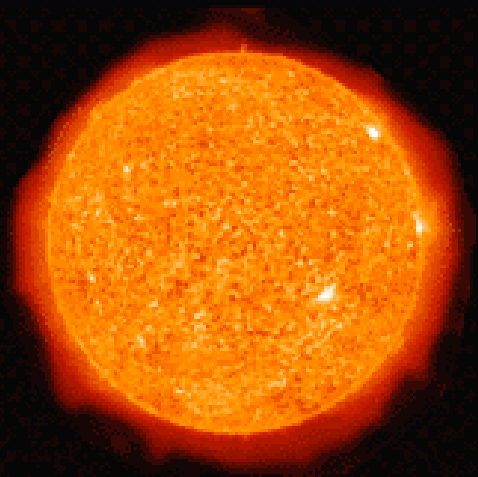
Mission Definition Participants

GEC - A Solar Terrestrial Probes Mission

- **Jan J. Sojka, Chair**
Utah State University
 - **Roderick A. Heelis, Co-Chair**
University of Texas at Dallas
 - **William A. Bristow**
U. Alaska, Fairbanks
 - **James. H. Clemmons**
Aerospace Corporation
 - **Geoffrey Crowley**
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 - **John C. Foster**
MIT Haystack Observatory
 - **Timothy L. Killeen**
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 - **Craig Kletzing**
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 - **Larry J. Paxton**
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 - **William K. Peterson**
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 - **Robert F. Pfaff, Jr**
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 - **Arthur D. Richmond**
NCAR
- GEC Project/Program*
- **Janette C. Gervin/ Mary S. DiJoseph**
NASA/GSFC
 - **Joseph M. Grebowsky**
NASA/GSFC
 - **Mary M. Mellott**
NASA Headquarters

Sun-Earth Connection

Geospace Electrodynamic Connections (GEC) Mission



GEC (in situ)

electrodynamic coupling of
ionosphere-magnetosphere-
atmosphere system (space/
time resolved)

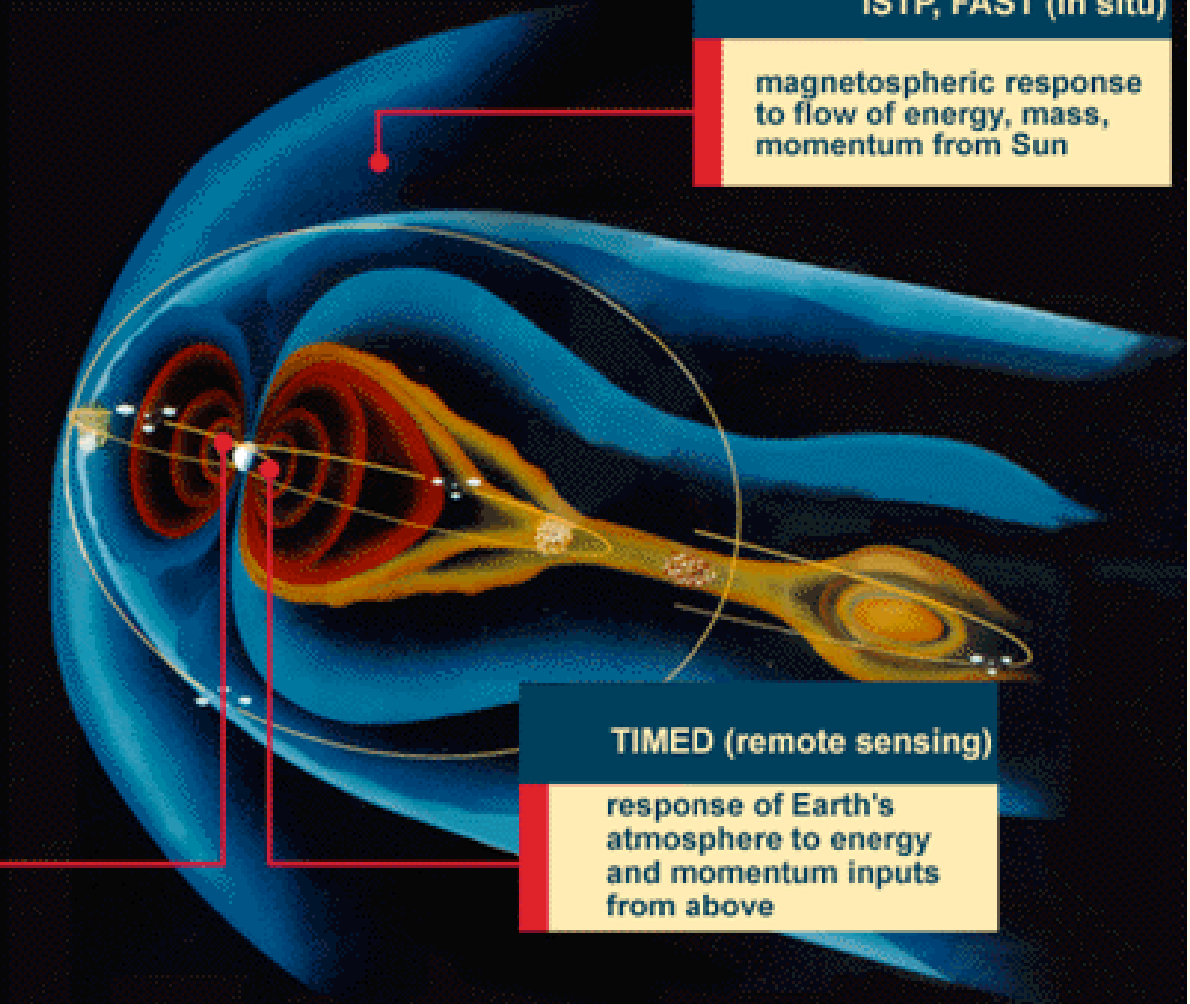


IMAGE (remote sensing)
ISTP, FAST (in situ)

magnetospheric response
to flow of energy, mass,
momentum from Sun

TIMED (remote sensing)

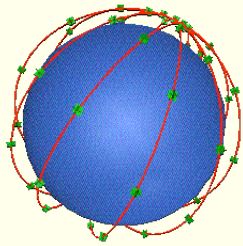
response of Earth's
atmosphere to energy
and momentum inputs
from above

Lower Ionosphere Thermosphere

General Importance



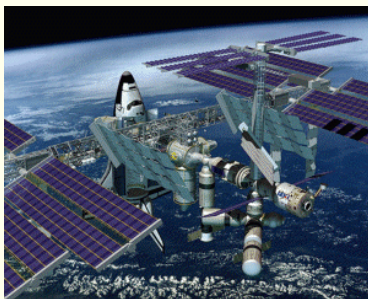
The dissipation of magnetosphere energy is manifest in the appearance of aurora.



Charged particle distributions contain irregularities that can disrupt navigation and communication signals



Horizontal closure currents induce electric fields and currents at the Earth's surface



Neutral atmosphere perturbations affect the orbits of small and large vehicles

GEC'S GOAL: ANSWER 3 QUESTIONS

- **How does ionosphere-thermosphere system respond to and dynamically affect magnetosphere-ionosphere coupling?**
- **How are ion and neutral motions coupled through the global ionospheric wind dynamo?**
- **How does the ionosphere-thermosphere system provide closure paths for field-aligned currents?**

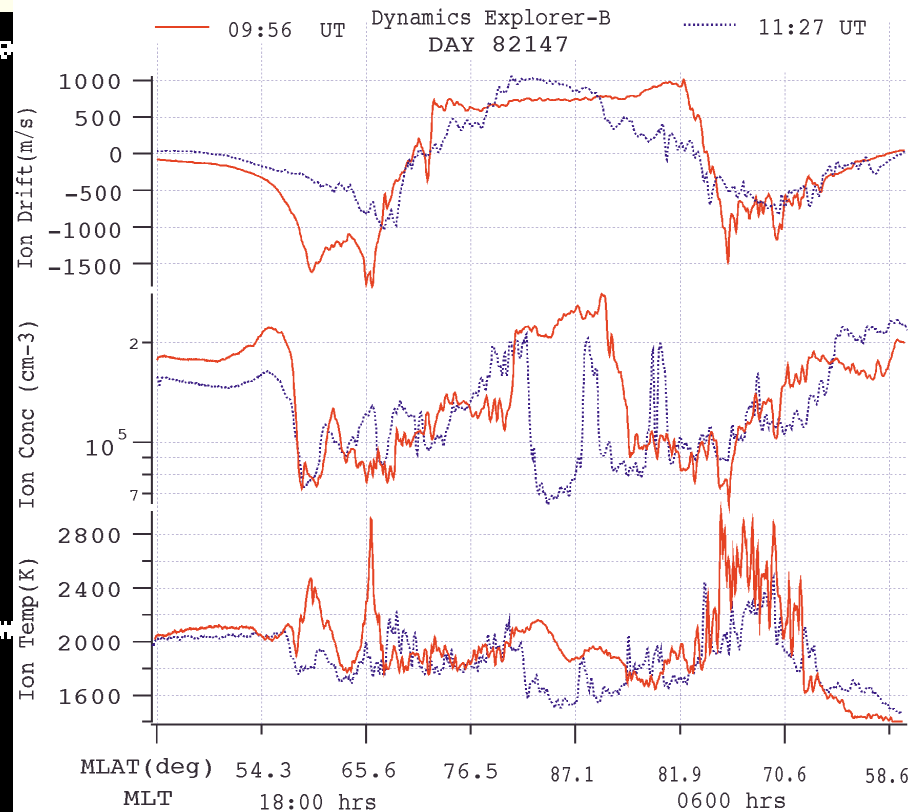
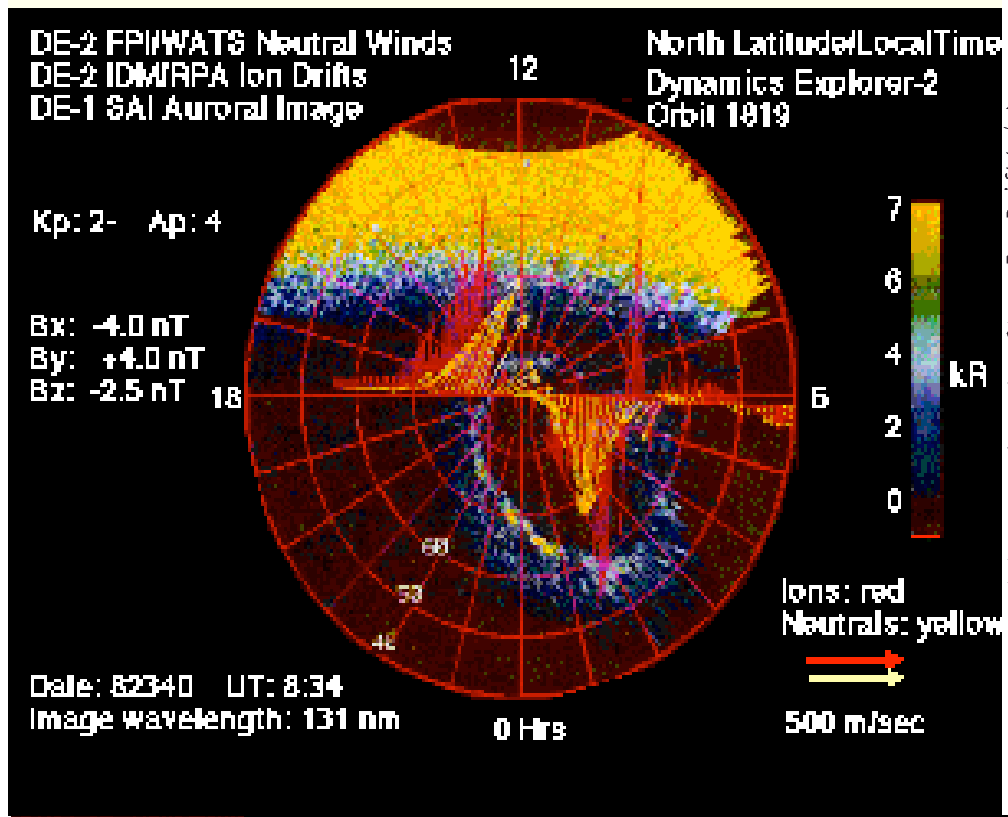
Electrodynamic Connections Can Become Uncorrelated in One Orbit

NASA Dynamics Explorer Mission (Early 1980)

DE-2 could measure many of the
electrodynamic connection parameters
and the ionosphere-thermosphere state
parameters.

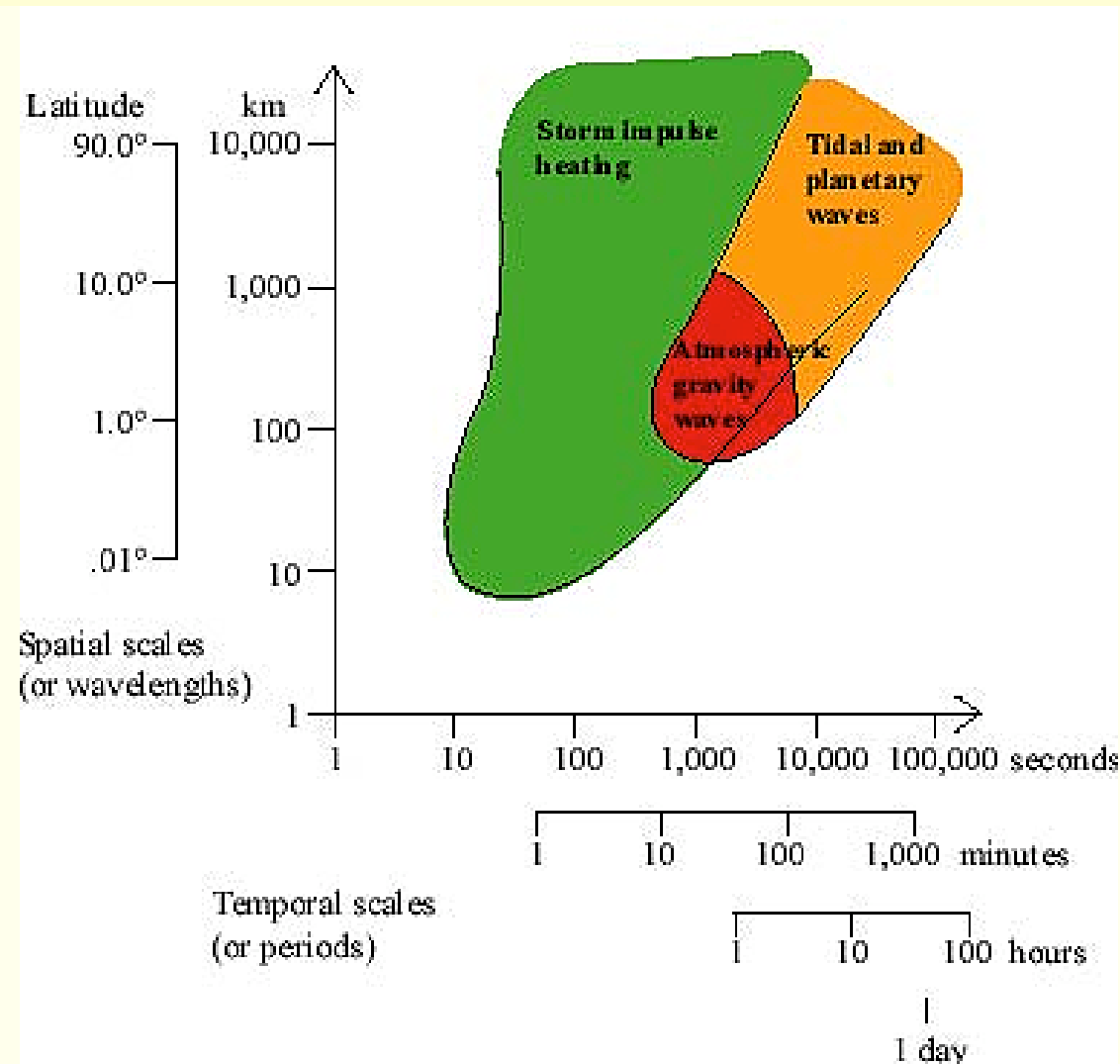
But

90 minutes later, the next DE-2 orbit,
these parameters were
UNCORRELATED.



First ORBIT is Red Trace
Second ORBIT is Blue Trace
These Data are Completely Space-Time Ambiguous

RELEVANT IONOSPHERE AND THERMOSPHERE SCALES



Time scales: seconds to days; spatial scales: kilometers to global.

GLOBAL AND REGIONAL MODELS OF IONOSPHERE- THERMOSPHERE EXIST

NCAR TIEGCM - 11 January Geomagnetic Storm

But

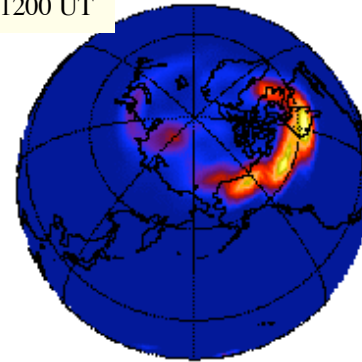
Primary weather inputs of Joule and
Frictional Heating are uncertain to factors of
2 or more

Because

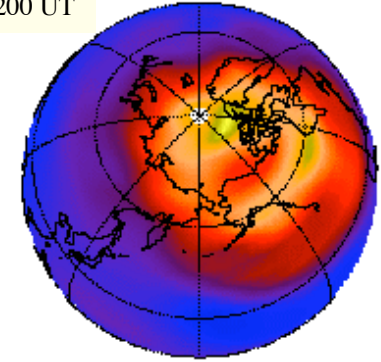
We do not know the critical spatial or
temporal scales for efficient energy transfer
between the magnetosphere, ionosphere,
thermosphere.

GEC will provide the
answer

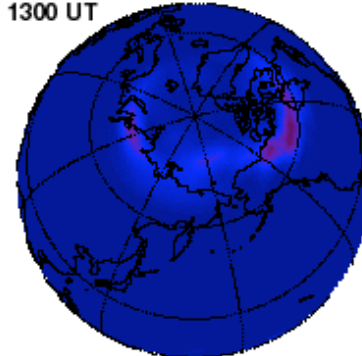
1200 UT



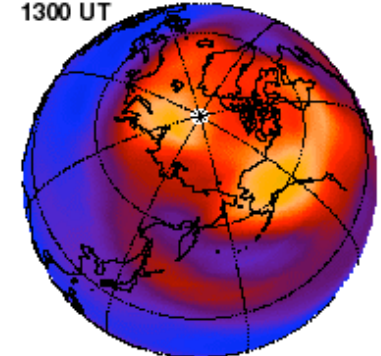
1200 UT



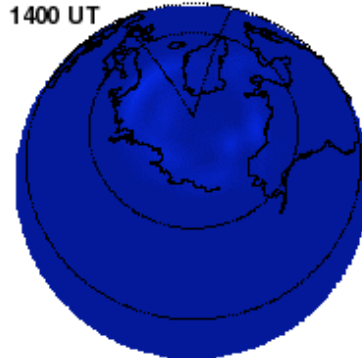
1300 UT



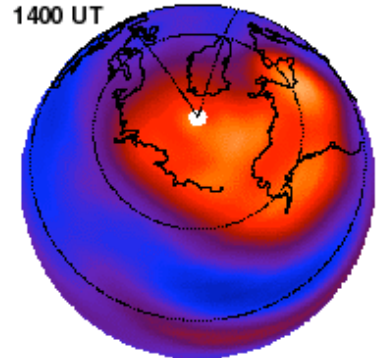
1300 UT



1400 UT



1400 UT

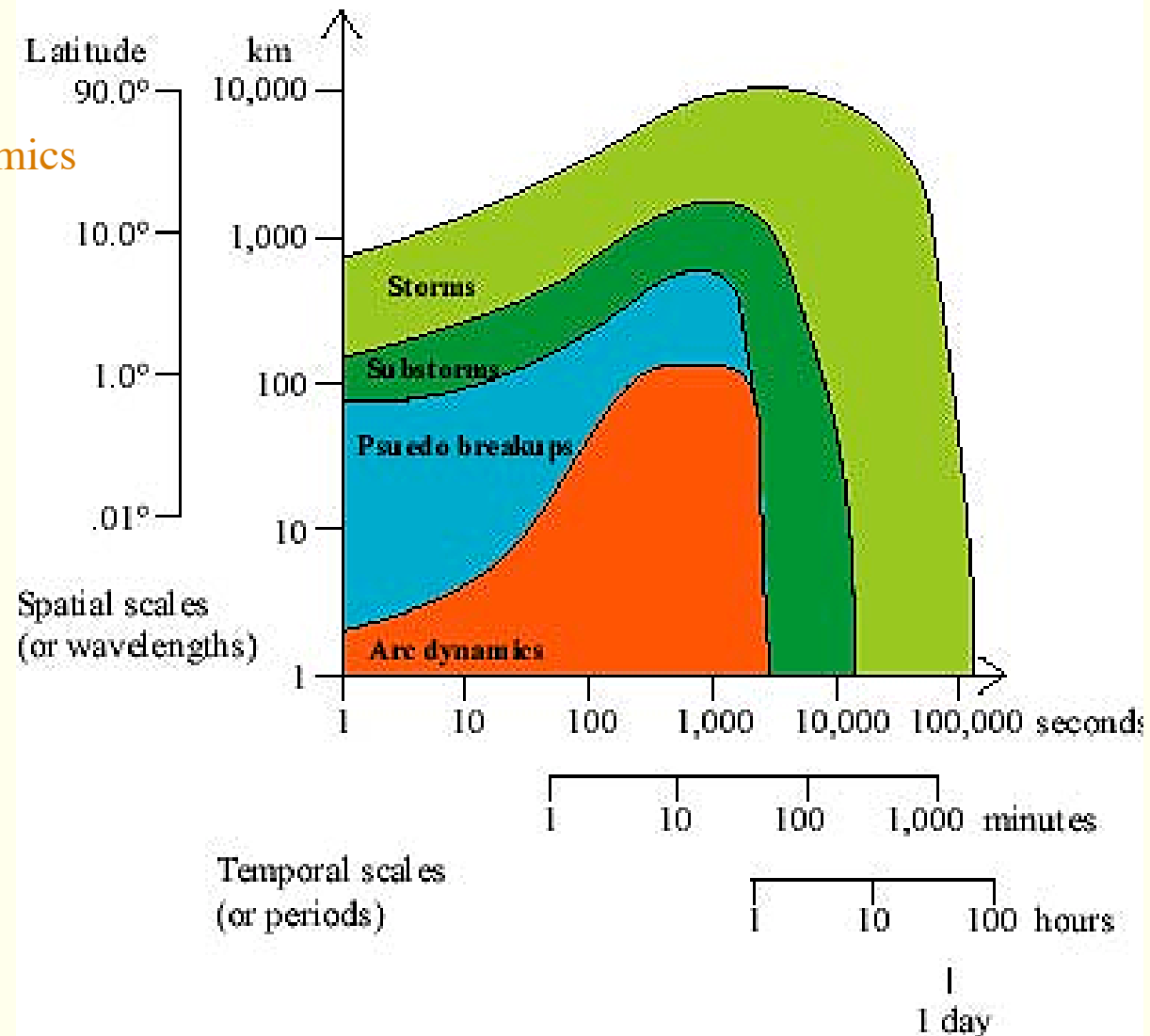


Input Joule Heating

T Increase @300 km

RELEVANT GEOSPACE ELECTRODYNAMIC SCALES

Auroral arc dynamics
Pseudo-breakups
Substorms
Storms

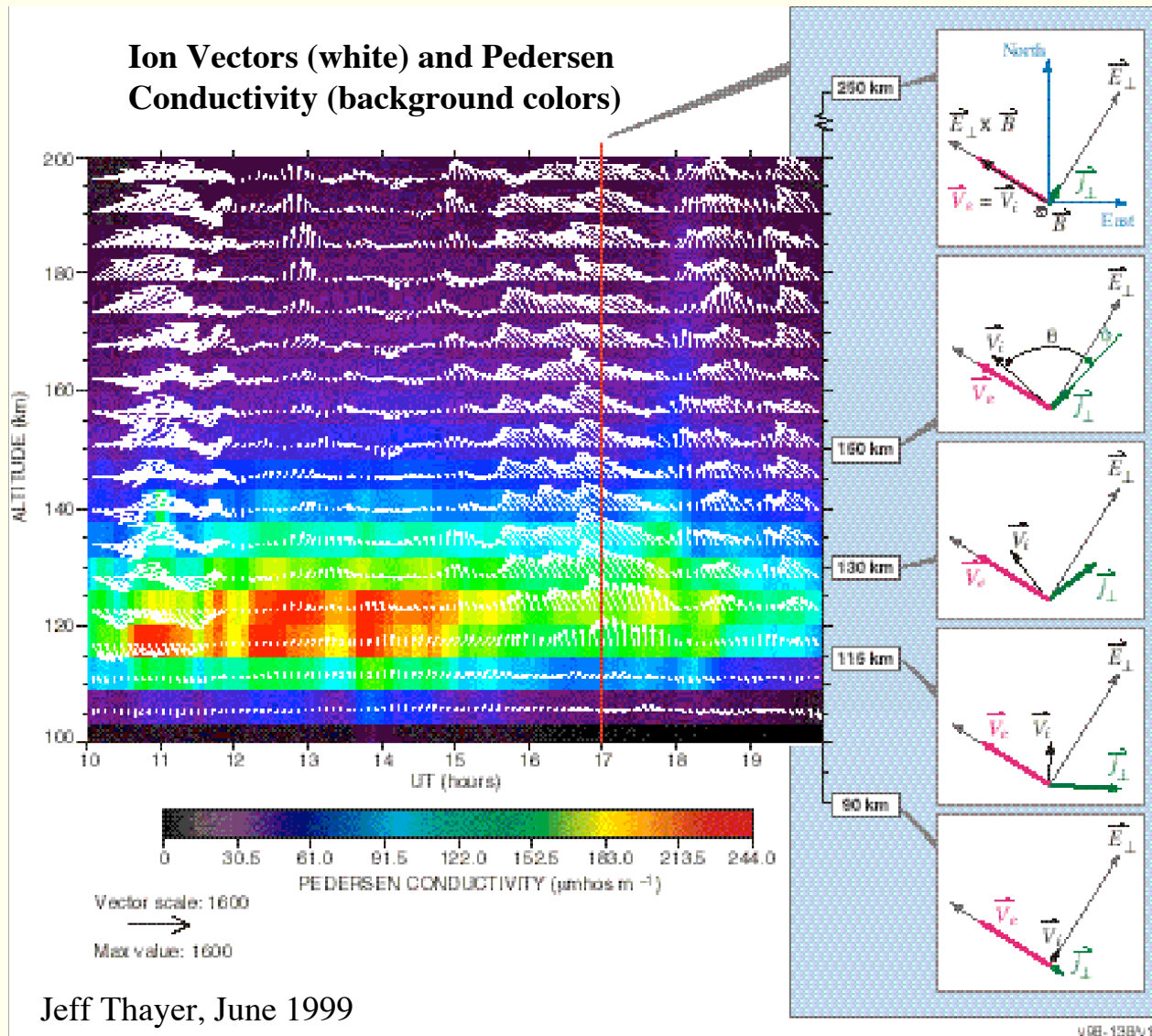


Characteristic spatial scales are less than 1 km and global and time scales are less than a second to days.

STRATEGIC OBJECTIVES

- 1. Measure and investigate electrodynamic processes in the ITM system including a detailed investigation of the important temporal and spatial scales for E-M energy transfer and energy distribution.**
- 2. Determine the cross-scale coupling processes that influence the interaction of the ionosphere-atmosphere system with the magnetosphere.**

Altitude Variation of Pedersen Current



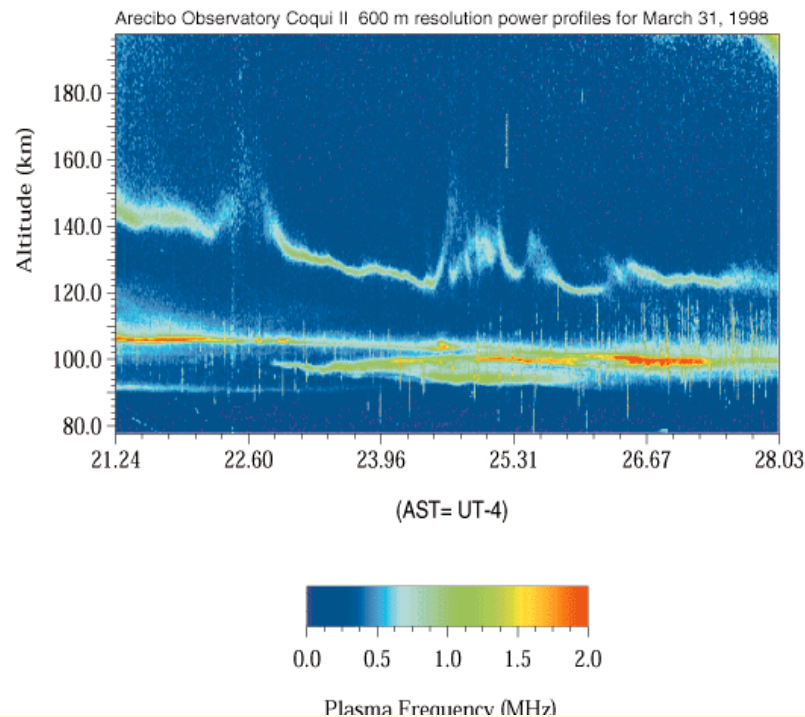
Sondrestrom ISR
(6 km vertical,
5 minute time
resolution).

Vector diagrams
show calculated ion
motion and current
at 5 altitudes for
same time.

**Median Altitude for Pedersen Current Closure is ~130 km
- GEC's Targeted Altitude.**

At 130 km, the Ionosphere Can Already Be Structured!!

*Metallic ion layers - meteoritic debris foams
Extremely narrow moving ionospheric layers*



Ionospheric electron density is color coded with blue being lowest and red highest density

What Must GEC Measure*

Ionosphere Thermosphere State Variable

- Electron Density
- Ion Composition
- Neutral Density
- Neutral Composition
- Ion and Neutral Temperature

Electrodynamic and Thermospheric Fields

- Electric Field Vector
- Magnetic Field Vector
- Neutral Wind Vector

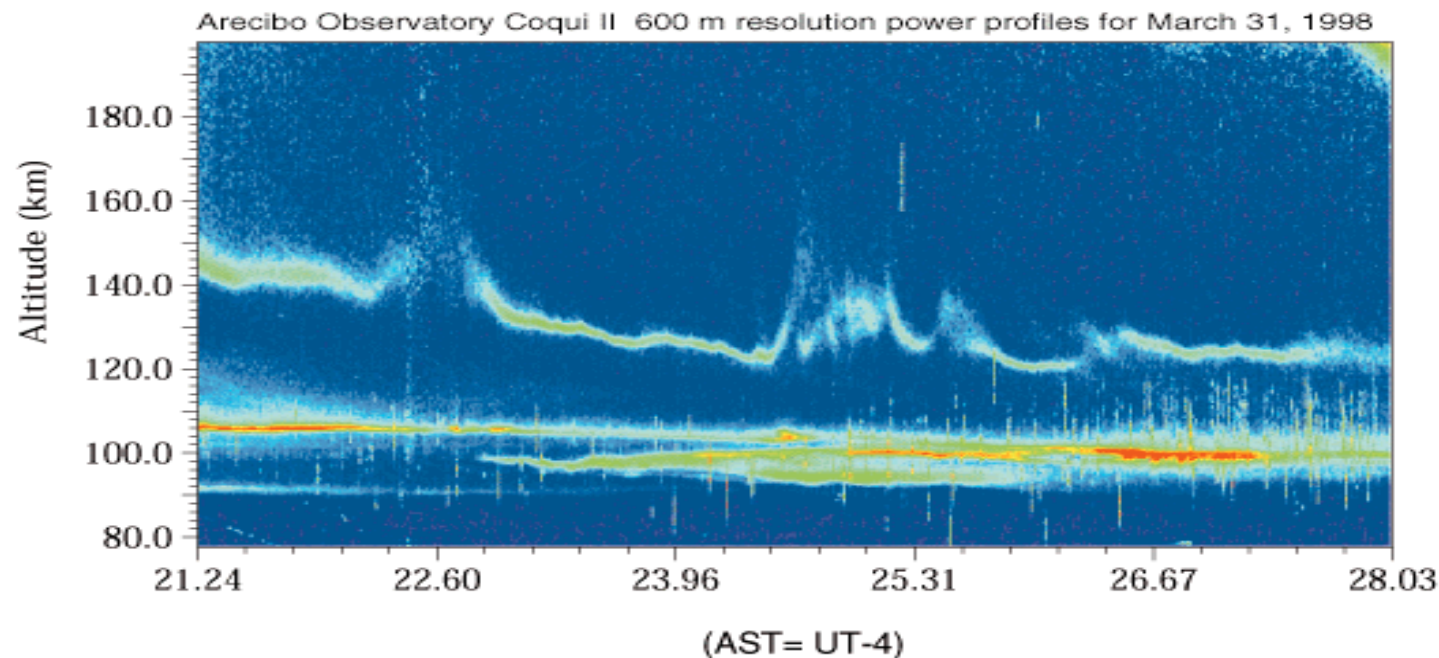
Auroral Precipitation

- Electrons
- Ions

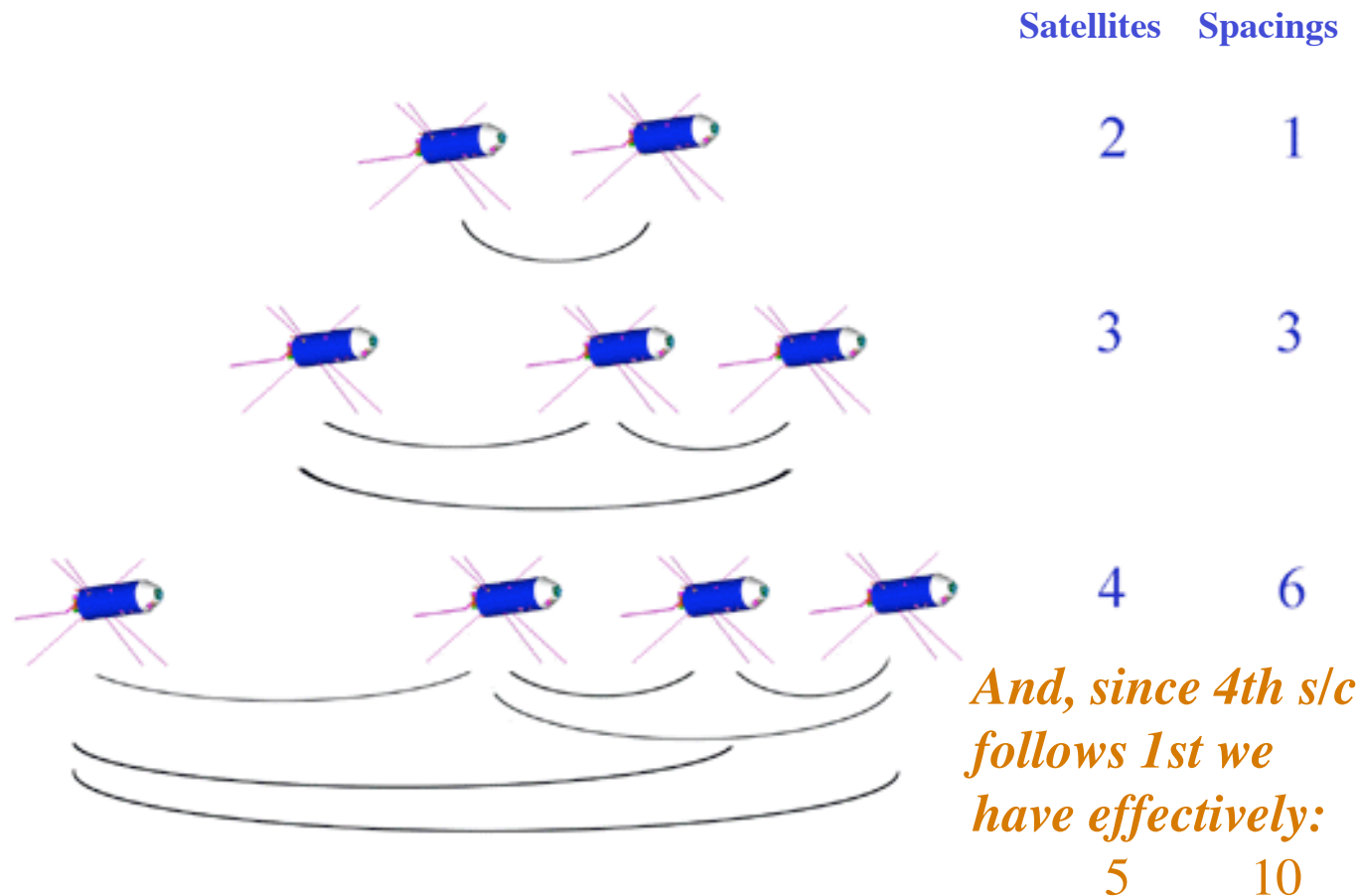
*These must all be sampled simultaneously in the same region of space with similar precision.

Mission Capabilities

- Four identical spacecraft: 83° inclination; 185 X 2000 km parking orbits; 326 kg of fuel per s/c for “dipping” campaigns below 130km.
- In situ sensors measure all relevant ionosphere/thermosphere parameters and use 4 s/c to separate time/space variations.



GEC'S FOUR SPACECRAFT MULTIPLE SCALE MEASUREMENTS



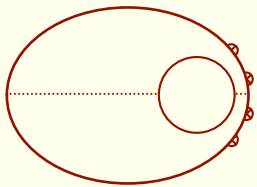
Pearls-on-a-string configuration with uneven spacing obtains information on many time/spatial scales.

MULTIPLE SATELLITE CONCEPTS

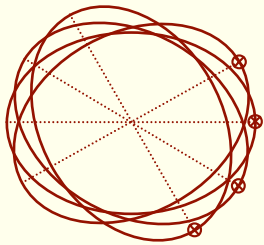
- The GEC mission plans to fly four spacecraft in formation, with all s/c periodically dipping to 130 km during planned campaigns

- *Several formations have been discussed for GEC*

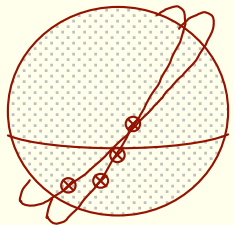
- ‘**String of Pearls**’ - s/c fly in formation in same orbit at varying distances



- ‘**Petal**’ - s/c perigees are staggered in latitude. Individual s/c are phased in their orbits to obtain altitude profiles.



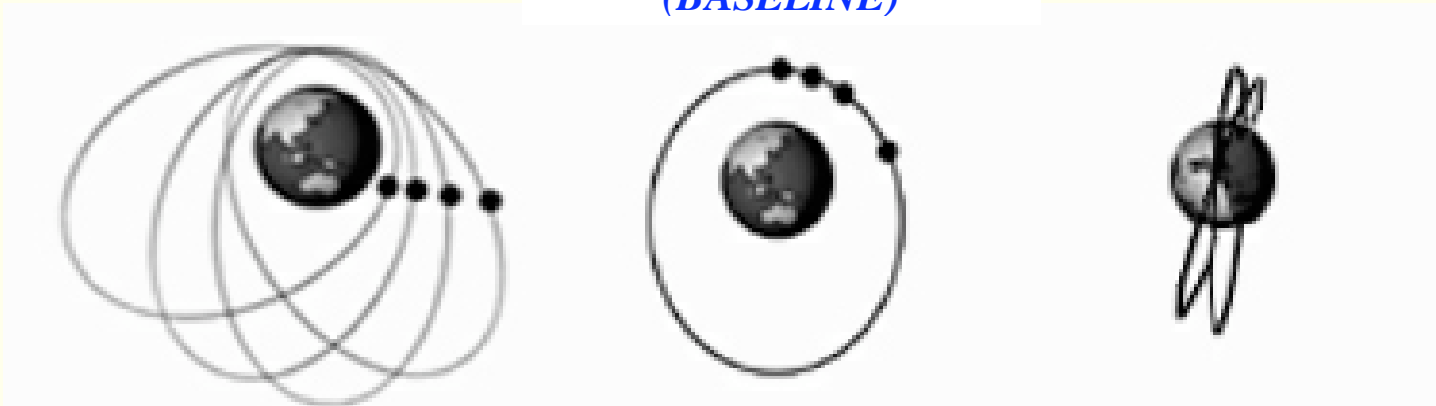
- **Local Time separations** - one s/c orbit is staggered in local time relative to the other three s/c



- *These configurations require maneuvers to establish and maintain the formation - in addition to performing dipping campaigns*

GEC ORBIT CONFIGURATIONS

*PEARLS-ON-A-STRING
(BASELINE)*



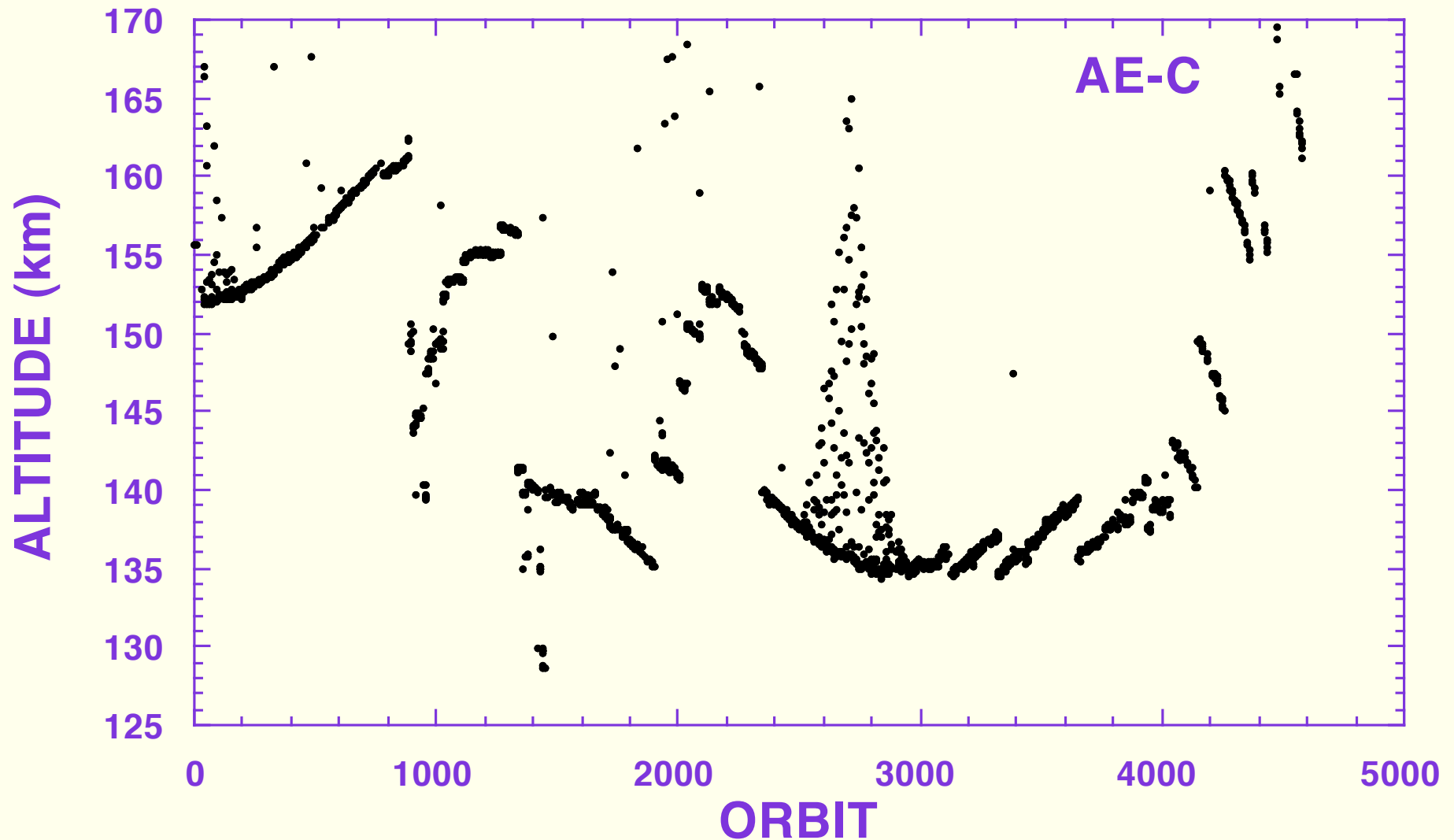
*PETAL FORMATION
(RESOLVE ALTITUDE STRUCTURE)*

*PLANE CHANGE
(END OF MISSION?)*

Atmosphere Explorer C Eccentric Orbit Perigees

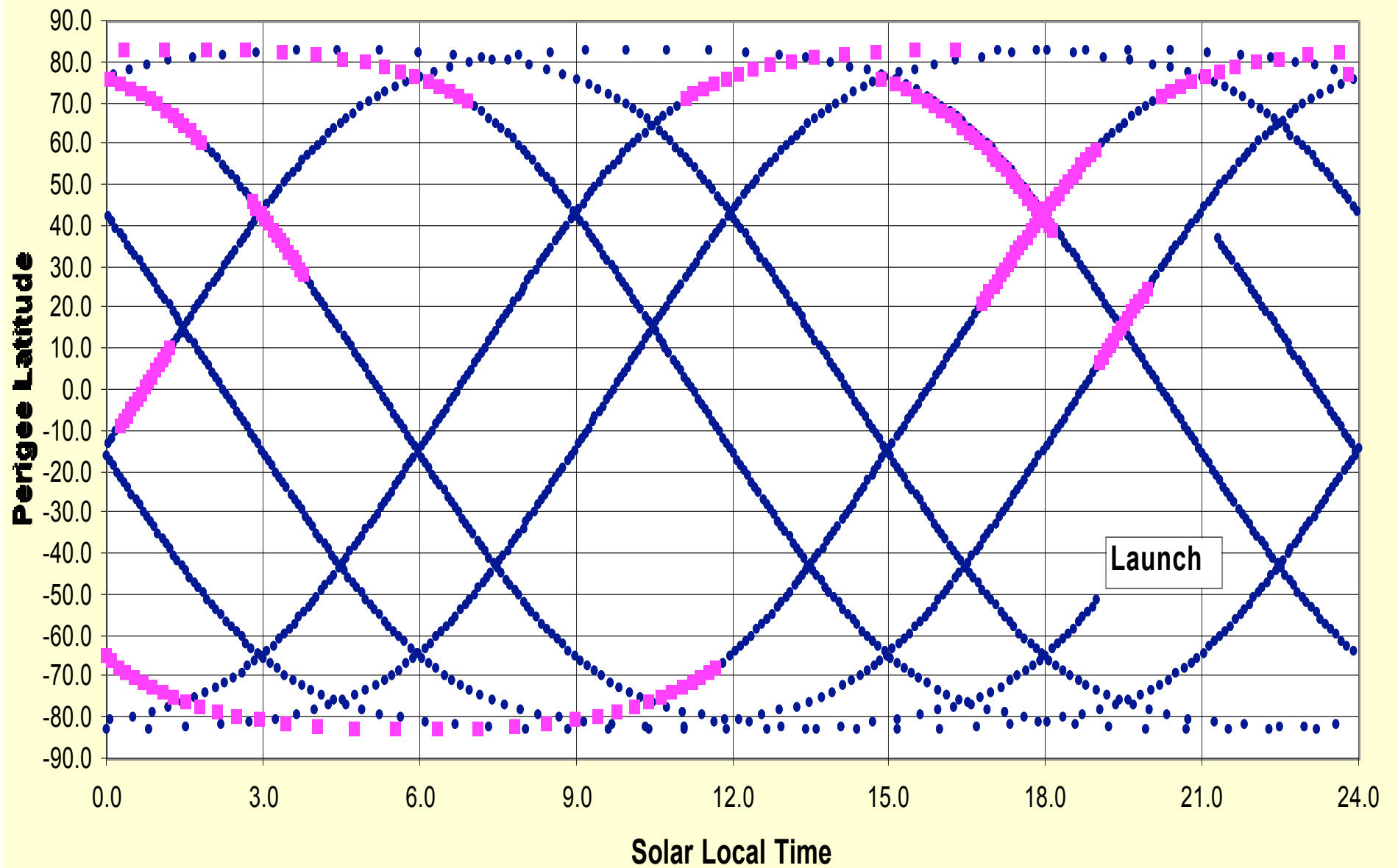
(From day 350, 1973 to day 365, 1974)

Lowest altitudes reached were just below 129 km

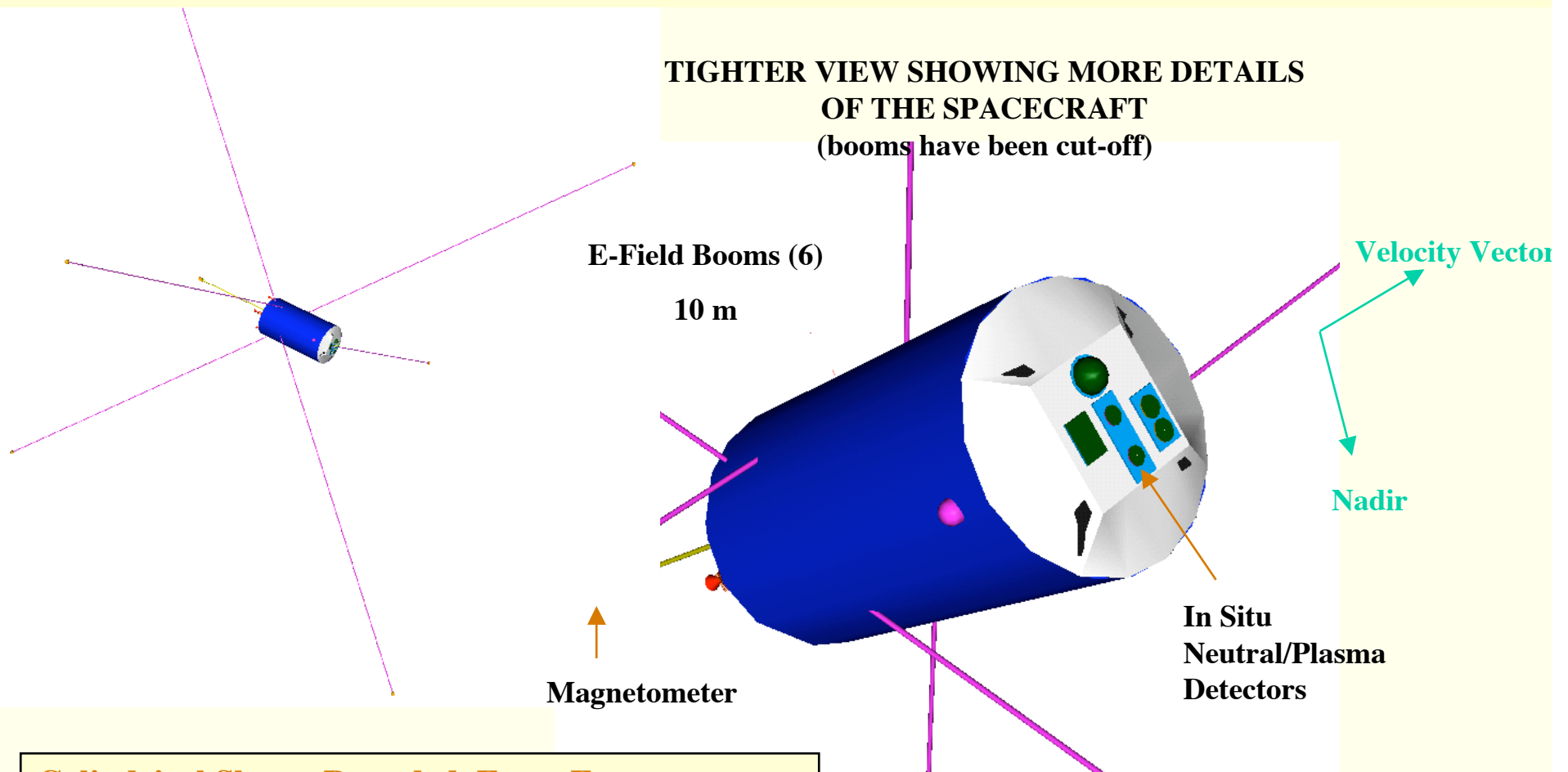


Perigee Latitude vs Local Time

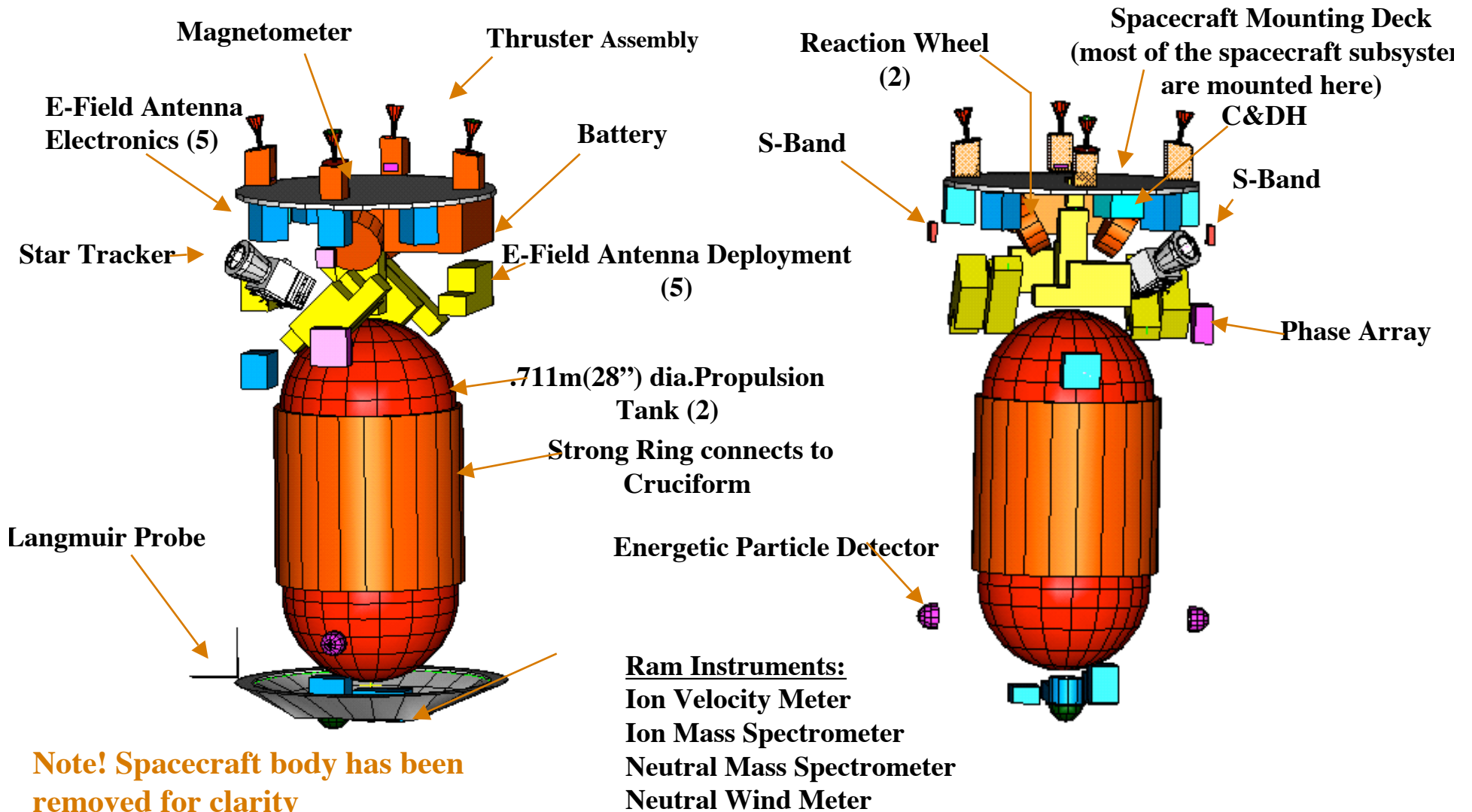
Dipping Campaigns in
purple



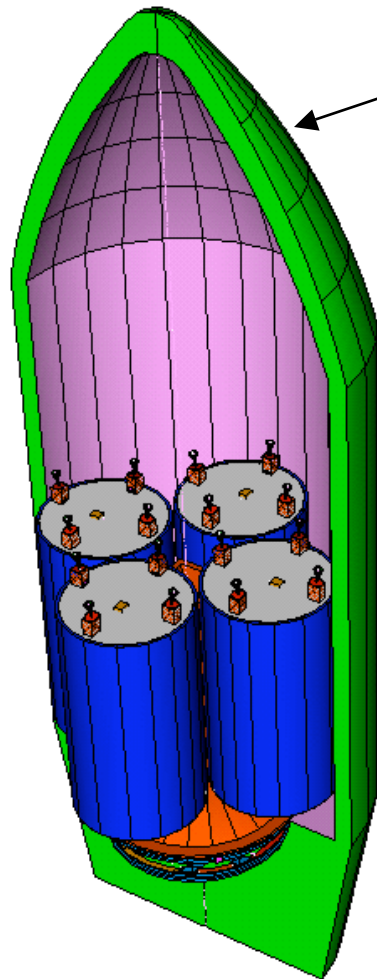
DESIGNED TO OVERCOME DRAG AND ELECTROMAGNETIC DISTURBANCE



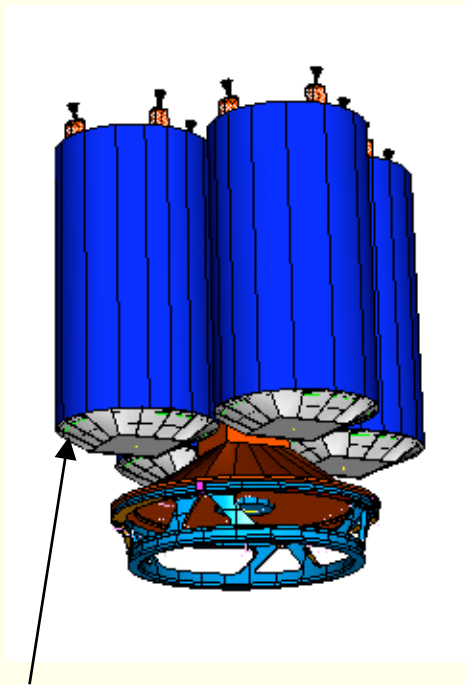
GEC COMPONENT LAYOUT



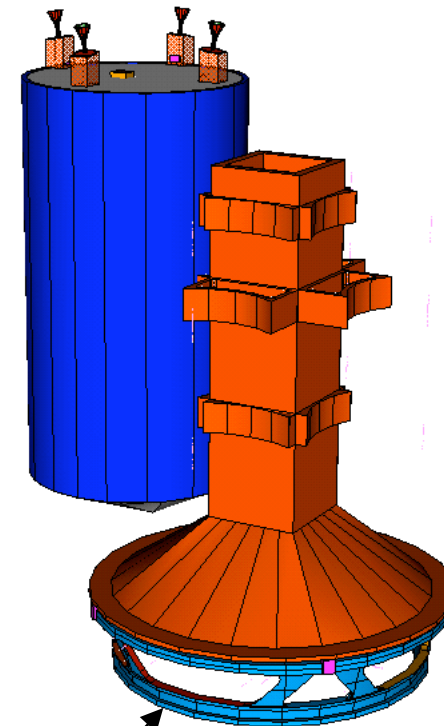
MULTI- SPACECRAFT LAUNCH PACKAGING



DELTA 7920H-10 Baseline



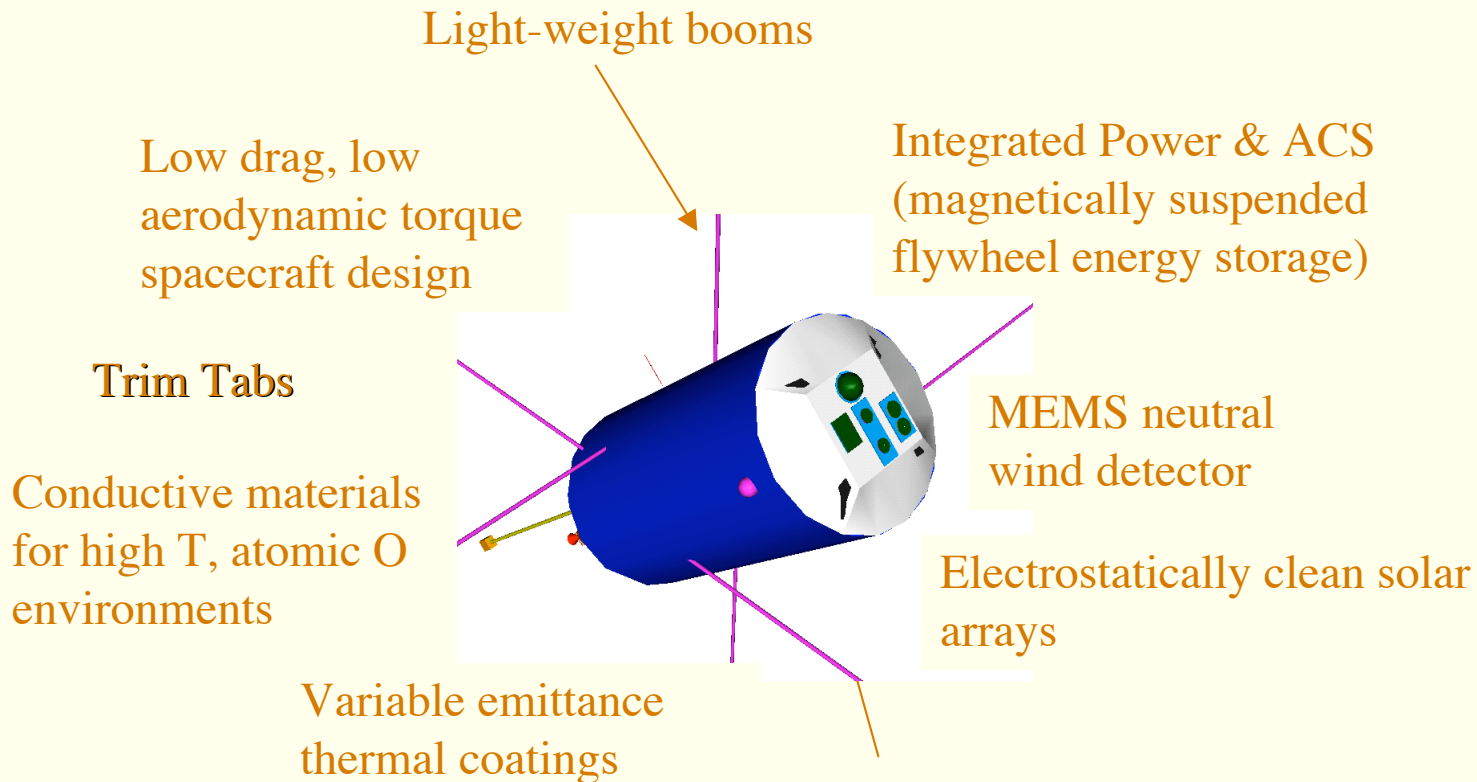
6915 PAF



CRUIFORM CONCEPT

1.1 M DIA. X 2 M LONG

New Technologies

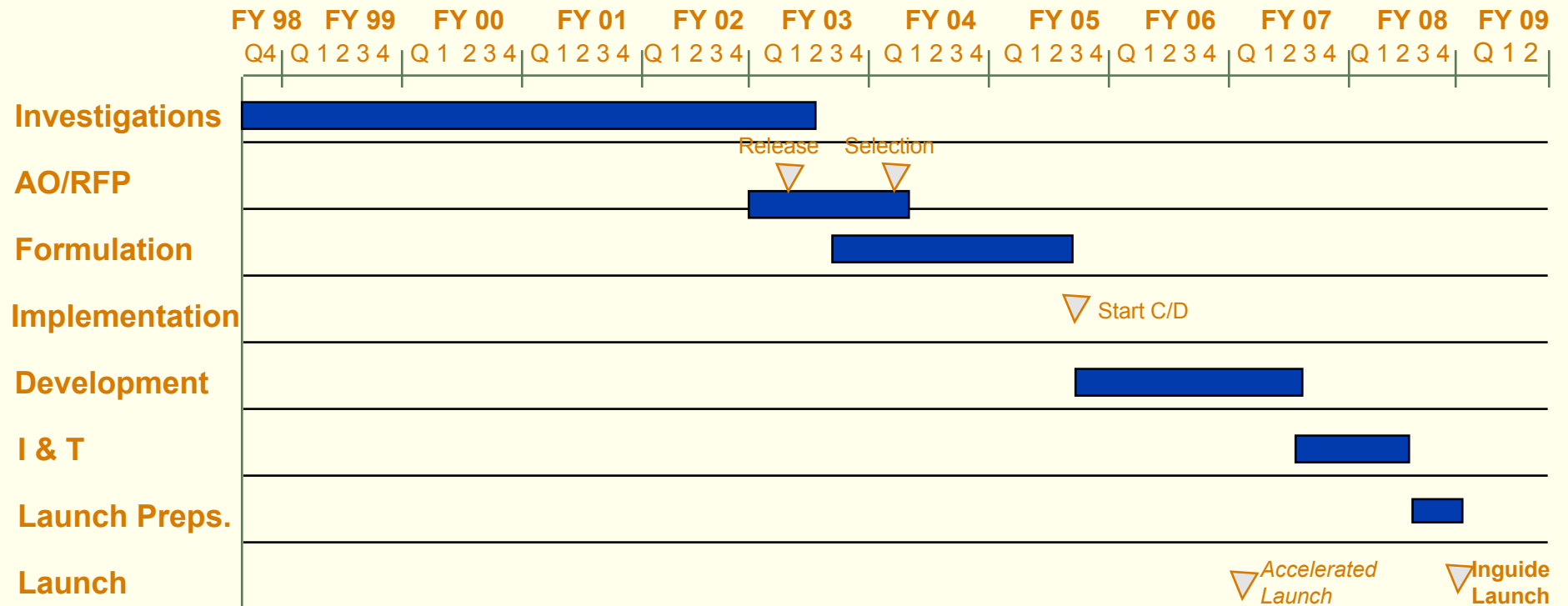


Also:

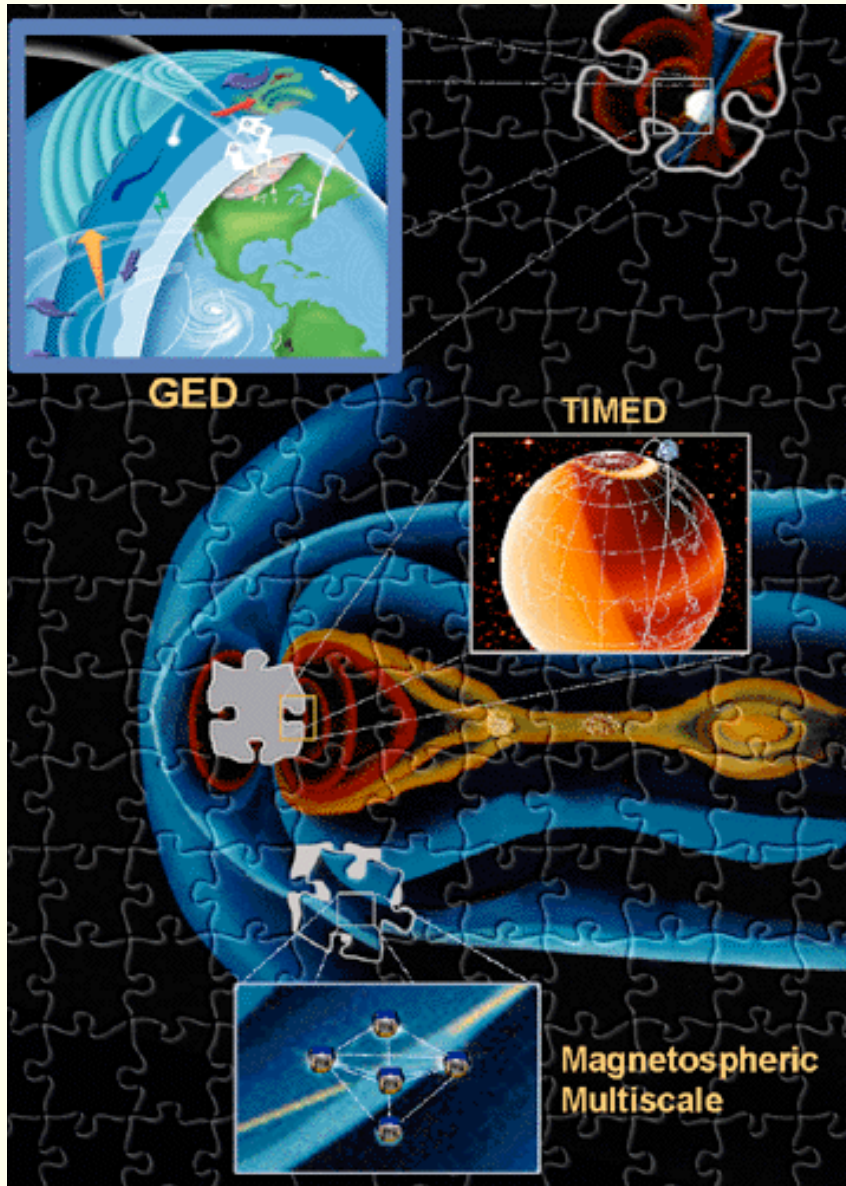
- Formation flying techniques/ground system control**
- Real time coordination of s/c and ground radar measurements**

GEC In-Guide Schedule

120 Million (USA \$) Implementation



Summary



- GEC will help to bring closure to our understanding of the inseparable role the thin electrically conducting region at the top of our atmosphere plays in the coupling of solar wind energy, through the magnetosphere down to the upper atmosphere.
- Multiple dipping s/c are used, otherwise the broad range of coupled, spatial and temporal scale processes would not be resolvable.
- GEC's focus is on a needed piece of the Sun-Earth Connection puzzle, complementing ISTP, MMS, IMAGE, and TIMED missions.